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TOXICITY OF PYRETHRIN/PYRETHROID FOGGER PRODUCTS TO BROWN TREE SNAKES, *BOIGA IRREGULARIS*, IN CARGO CONTAINERS

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Abstract: We tested 3 insect fogger products as fumigation devices for toxicity to brown tree snakes (*Boiga irregularis*) in cargo containers on Guam. These insecticide fogger products are registered with the U.S. Environmental Protection Agency (EPA) for use in homes, garages, attics, basements, hospitals, hotels, railroad cars, truck trailers, warehouses, and zoos for the control of cockroaches, ticks, crickets, earwigs, spiders, mosquitoes, and wasps. We found that a smoke-fumigator containing 12.6% permethrin failed to kill snakes, whether they were exposed or semi-protected (in cloth bags). A fogger containing 0.5% pyrethrin and 0.1% cyfluthrin (a synthetic pyrethroid) and the synergist 1% piperonyl butoxide, killed 6 of the 18 exposed snakes in a 3 hr exposure period but killed none of the 18 semi-protected snakes. A fogger containing 0.535% pyrethrin with two synergists (1.05% piperonyl butoxide and 1.71% n-octyl bicycloheptene dicarboximide) killed 4 of the exposed snakes; none of the 18 bagged snakes died. All snakes that were killed died within 24 hr after treatment; survivors showed no overt symptoms of intoxication.

Key words: Pyrethrins, Pyrethroids, Insecticide Foggers, Brown Tree Snakes, *Boiga irregularis*

The introduced brown tree snake, (*Boiga irregularis*), has extirpated several species of indigenous birds on the island of Guam and is currently threatening several others (Savidge, 1987). The snakes are significant pests of agriculture, public health and safety (Fritts *et al.*, 1994) and cause substantial economic losses (Fritts, 1988). Since Guam is the focal point for transport of air and sea cargo to many other parts of the Pacific and the continental United States, a high risk exists for these snakes to be introduced to new areas in cargo shipments. Methods are needed for managing snake populations on Guam and for reducing risks of their introduction to other areas. Fumigation of cargo is one of several methods available for brown tree snake management on Guam and elsewhere and a fumigant, methyl bromide, was found to be effective (Savarie *et al.*, 1998); subsequently, brown tree snakes have been added to its label. In 1995, we further demonstrated the effectiveness of two other highly toxic and restricted use fumigants; sulfuryl fluoride and phosphine (Savarie *et al.*, 1995) when used at doses registered with the U.S. Environmental Protection Agency (EPA). These conventional fumigants, labeled for Restricted Use Only, are hazardous to use and may only be applied by trained and experienced personnel.

Some possible alternatives to conventional fumigants would be the insecticide fogger products registered with EPA for the control of cockroaches, fleas, ticks, crickets, earwigs, spiders, mosquitoes, and wasps. The fogger products are General Use pesticides and, according to the labels, they can be used in areas such as homes, garages, attics, basements, pet areas, hospitals, hotels, campers, railroad cars, ships, supermarkets, truck trailers, warehouses, and zoos. These materials are readily available and easy to use. If effective, and if their labels could be amended to include brown tree snakes, they could be used by the general public in household/urban situations as well as by transportation personnel as cargo fumigants.

*Mention of trade names does not constitute endorsement by The U.S. Department of Agriculture.

Materials and Methods

We had previously determined that several pyrethrins/pyrethroids were orally and dermally toxic to brown tree snakes (Brooks *et al.*, 1995). We chose three fogger products for tests with snakes exposed in cargo containers on Guam; those chosen contained pyrethrins/pyrethroids, with or without synergists. The foggers were of two types: 1) quick release foggers in (170 g net weight) pressurized containers and 2) a fumigating fogger in a metal can (140 g total weight; 9.9 g net weight) which releases a smoke containing a synthetic pyrethroid when water is added. The three products examined were:

1. **RAID Fumigator Fumigating Fogger*** (EPA Reg. No. 4822–278), containing 12.6% permethrin (CAS #52645–53–1) as the active ingredient and 87.4% inert ingredients.
2. **Pro-Control II Total Release Fogger** (EPA Reg. No. 11540–27), containing 0.535% pyrethrin (CAS #8003–34–7), 1.050% piperonyl butoxide (CAS #51–03–6), 1.710% N-octyl bicycloheptene dicarboximide (CAS #113–48–4), and 96.705% inert ingredients.
3. **Pro-Control IV Total Release Fogger with Cyfluthrin** (EPA Reg. No. 11540–24), containing 0.50% pyrethrin, 0.10% cyfluthrin (CAS #68359–37–5), 1.00% piperonyl butoxide and 98.40% inert ingredients.

Brown tree snakes, captured in live traps on Guam, were transferred from traps into either wire holding cages or cloth bags for transport to a holding facility located at Andersen Air Force Base (AAFB). Snakes were weighed in cloth bags before being individually caged in plastic boxes with airholes on the sides. Each snake was assigned a unique accession number. Each cage contained newspaper on the bottom and a double-walled plastic dish with a hole cut into the side; this served as a water container and shelter. Water and paper were changed weekly. After caging, snakes were quarantined for a minimum of 3 days and then examined for general health by a veterinarian. Snakes were randomly allocated to treatment groups based upon body weight. For each treatment, 18 snakes were placed in cotton bags (semi-protected from the contents of the foggers) and 18 were placed in cages made of 1/4 inch wire mesh (exposed directly to fogger contents). Snakes were randomly allocated by pairs to 18 positions inside a 6.1×2.44×2.44 m (internal dimensions) cargo container. Snakes were positioned in 6 rows from the front to back of the container and, within each row, placed in pairs at positions high (2 m), medium (1 m), or low (just above the floor).

The foggers were released by placing them on the floor between rows 3 and 4 in the center of the container during the evening hours, after the container cooled to about 30°C from its daytime high of 37–38°C. The fogger devices were weighed before and after treatment to calculate the amounts of active ingredients released. High and low temperature and humidity data were taken during the exposure period with a digital hygrometer/thermometer instrument. The container doors were closed and rubber strips effectively sealed the container doors. Small ventilation holes inside each container were sealed with paper tape. The snakes were exposed for 3 hours after which the doors were then opened for ventilation of the containers for 30 min (fogger labels called for at least a 2 hr exposure period). All snakes were removed at the end of the exposure and ventilation period and returned to their cages. They were then observed for 7 days for general health or mortality.

Results and Discussion

The mortality of brown tree snakes when exposed to insecticide foggers inside cargo containers is shown in Table 1. The two pyrethrin products killed snakes that presumably were directly exposed to fog droplets. For both fogger pyrethrin products, only some of the snakes in wire cages in the center two rows and at each end of the cargo container were killed. All snakes died within 24 hr following the treatments. None of the snakes contained in cloth bags were killed nor did they exhibit any post-treatment signs of intoxication. The smoke-

Table 1. Active ingredient dosages and mortality of brown tree snakes (n=18 per treatment) exposed to insecticide fogger products in cargo containers on Guam, August/September 1995.

Product	Dosage*	% Snake Mortality	
	(g/m^3)	Cloth bags	Wire cages
PRO-CONTROL FOGGER		0	33
Cyfluthrin 0.10%	0.005		
Pyrethrin 0.50%	0.025		
Piperony butoxide 1.0%	0.050		
PRO-CONTROL FOGGER		0	22
Pyrethrin 0.535%	0.027		
Piperony butoxide 1.05%	0.054		
n-Octyl bicycloheptene dicarboxmide 1.71%	0.088		
RAID FUMIGATOR		0	0
Permethrin 12.6%	0.29		
UNTREATED CONTROLS		0	0

*Calculated from the amount of active ingredients released during treatments as determined from the weight changes of the foggers or by stated net contents of active ingredients. The cyfluthrin/pyrethrin fogger released 167.6 g; the pyrethrin with synergists released 173.0 g; and the permethrin fogger contained 9.9 g of active ingredient.

expelling fumigator product containing permethrin did not kill any snakes, whether in cotton bags or in wire cages and none of these snakes showed signs of intoxication during the 7 day observation period. This result was consistent with our previous observation that permethrin was only slightly toxic to brown tree snakes (Brooks *et al.*, 1995).

The estimated dosages of active ingredients released in the cargo containers for the Pro-Control foggers were cyfluthrin, 0.005 g/m^3 and pyrethrin, 0.025 g/m^3 and 0.027 g/m^3 for the fogger containing only pyrethrin. The estimated dosage of permethrin released was 0.29 g/m^3 based upon the net contents of 9.9 g per container. Temperatures during the treatments ranged from 25–30°C and relative humidity from 79–100%.

Snakes held inside cotton bags survived without poisoning symptoms. This result suggests that snakes concealed inside cargo would not be affected by any of these products. Only snakes that receive a sufficient dose of fog droplets directly on their bodies at the immediate time of release may be expected to die. Inhalation of the pyrethroid smoke (permethrin) by exposed snakes apparently did them no harm since for 7 days post-treatment they showed no signs of intoxication.

Labels on the Pro-Control foggers state they will treat spaces of 5000 ft^3 (about 140 m^3), while those on the RAID Fumigator state it treats a room 16×20 feet (approximately 2500 ft^3=70 m^3). The interior volumes of the cargo containers used in this study approximate only 1200 ft^3 (33.6 m^3), so the dosages applied exceeded the recommended treatments in all cases. We concluded that pyrethrin/pyrethroid foggers products do not offer a viable alternative to conventional fumigation gases, such as methyl bromide, sulfuryl fluoride, and phosphine.

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要　約

貨物コンテナにおけるミナミオオガシラに対するピレスリン・ピレスロイド噴霧剤の毒性

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グアムにおける貨物コンテナ内のミナミオオガシラに対する薫蒸剤として，3種の殺虫噴霧剤の毒性をテストした．これらの殺虫剤は，米国環境保護協会により，家庭や公共の場所での害虫の駆除用に登録されている．12.6%のペルメスリンを含む燻煙で露出しているヘビの3分の1を殺したが，布袋に入っているヘビは殺すことができなかった．0.535%ピレスリンと2種の共力剤を含む噴霧剤は，露出しているヘビの4分の1弱を殺すことができたが，隠れているヘビはだめだった．死亡したヘビはいずれも処理後24時間以内に死んだが，生き残ったヘビには毒によるはっきりした症状は認められなかった．

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